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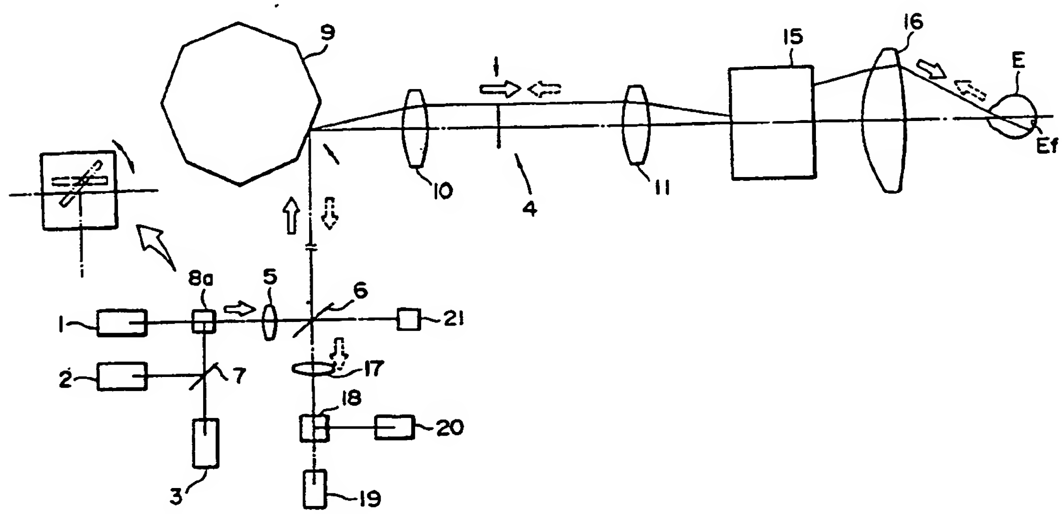
(54) **Laser scanning type eye fundus camera.**

(57) A laser scanning type eye fundus camera is designed as such that retina photographing for the first frame portion is performed with laser beams including two wavelengths among wavelengths of the primary three colors and retina photographing for the second frame portion is performed with two laser beams or less including the remaining one wavelength so as to obtain a retina image by the wavelengths of the respective primary colors and thereafter, they are composed to obtain one color retina image.

F I G . 1



EP 0 428 450 A1

LASER SCANNING TYPE EYE FUNDUS CAMERA

BACKGROUND OF THE INVENTION

Field of the Invention:

This invention relates to a laser scanning type eye fundus camera for scan projecting a laser beam onto the retina of an eye to be tested and receiving a reflected beam from the retina through a light receiving element and then color photographing the retina in accordance with a signal coming from the light receiving element.

Description of the Prior Art:

Heretofore, an illuminating light of somewhat strong (or intensified) energy has been used for projecting the same to the retina of an eye to be tested in order to carry out an observation photographing, etc. in a retina testing using a conventional eye fundus camera.

The test according to this conventional method gave a pain to the patient both physically and mentally.

In recent years, in order to diminish this burden or pain and enhance the safety of the testing, there was proposed a laser scanning type eye fundus camera in which a laser beam is scan projected to the retina so that a strong (or intensified) energy would not be irradiated to a particular part for a long period of time. Moreover, as a color photograph obtained by illuminating the retina with a white light is useful in an ordinary eye fundus testing, there has been contemplated a laser scanning type eye fundus camera by which a color photograph can be taken.

As such laser scanning type eye fundus camera which is capable of color photographing, there is one disclosed, for example, in USP4781453. In this laser scanning type eye fundus camera, the retina is photographed for each frame using a laser beam of wavelengths of four colors of R, G, B and Y, and retina images obtained by respective wavelengths are composed to obtain one color retina image.

However, when the retina should be photographed for each frame in sequence using four kinds of laser beams which have different wavelengths, it takes such a long period of time as required for four frame portions in order to obtain one color retina image. In such a long period of time, there is a fear that the retina image is changed due to movement of the eye to be tested. Owing to the foregoing reason, there is such a tendency as that a clear retina image becomes difficult to obtain because there occurs a slippage of respective images when such images of various wavelengths are composed.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a laser scanning type eye fundus camera which is capable of color photographing in a shorter period of time than the above-mentioned conventional eye fundus camera.

In order to achieve the above-mentioned object, the present invention includes laser beam generating means for generating laser beams having wavelengths of three primary colors;
a scanning optical system for scan projecting the laser beams to the retina of an eye to be tested;
switch means for selectively switching laser beams of various wavelengths coming from said laser beam generating means and guiding the same to said scanning optical system;
control means for controlling said switch means so as to selectively switch at least two laser beams among said three laser beams and permitting said scanning optical system to scan project one frame portion of such selected laser beams to the retina of the eye and also permitting said scanning optical system to scan project one frame portion of two laser beams or less including the remaining one among said three laser beams to the retina of the eye;a light receiving optical system for taking out a reflected light from the retina of the eye;
first light receiving means for receiving reflected light having two wavelengths among said wavelengths of said three primary colors which are guided by said light receiving optical system; second light receiving means for receiving a reflected light having the remaining one wavelength among said wavelengths of said three primary colors which is guided by said light receiving optical system;
andimage processing means for composing said various primary colors in accordance with output from said light receiving means in order to form a single color retina image.

These and other objects, features and advantages of the present invention will be well appreciated upon reading of the following description of the invention when taken in conjunction with the attached drawings with understanding that some modifications, variations and changes of the same could be made by the skilled person in the art to which the invention pertains without departing from

the sprit of the invention or the scope of claims appended hereto.

BRIEF DESCRIPTION OF THE ATTACHED DRAWINGS

Fig. 1 is a plan view showing an arrangement of an optical systems of a laser scanning type eye fundus camera according to the present invention;

Fig. 2 is a schematic side view showing the arrangement of Fig. 1;

Fig. 3 is a control circuit diagram of a laser scanning type eye fundus camera shown in Fig. 2;

Fig. 4 is a detailed view of a synchronous control circuit shown in Fig. 3;

Fig. 5 is an explanatory view showing photographing patterns of the laser scanning type eye fundus camera shown in Figs. 1 through 4;

Fig. 6 is an explanatory view showing another example of photographing patterns of the laser scanning type eye fundus camera shown in Figs. 1 through 4; and

Figs. 7 and 8 are arrangements showing another example of an optical path switch means shown in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The embodiment of the present invention will be described hereinafter with reference to the drawings. Figs. 1 through 5 show a first embodiment of the present invention.

In Fig. 1, a laser scanning type eye fundus camera has first, second and third lasers 1, 2 and 3 (laser generating means) for generating laser beams having wavelengths of three primary colors, i.e., B (Blue), G (Green) and R (Red). The lasers 1, 2 and 3 may include a laser emitting diode or the like. And, laser beams generated by the lasers 1, 2 and 3, etc. are made incident to the scanning optical system 4. In this case, a blue laser beam generated by the laser 1 is made incident to a scanning optical system 4 through a lens 5 and a half mirror 6 as beam split means. Similarly, a green laser beam generated by the laser 2 is made incident to the scanning optical system 4 through a dichroic mirror 7, a rotating mirror 8a of an optical path switch device 8 (optical path switch means), the lens 5, and the half mirror 6. Likewise, a red laser beam generated by the laser 3 is made incident to the scanning type optical system through the rotating mirror 8a of the optical path switch device 8 (optical path switch means), the lens 5 and the half mirror 6 after transmitting through the dichroic mirror 7.

The dichroic mirror 7 is provided with a coating material so that a laser beam of a green wavelength is reflected and a laser beam of a red wavelength is permitted to transmit. Accordingly, the rotating mirror 8a can be removably inserted into the optical path as will be described afterward. When the rotating mirror 8a is removed from the optical path, the blue laser beam is guided to the scanning optical system 4. On the other hand, when the rotating mirror 8a is inserted into the optical path 4, the green and red laser beams are guided to the scanning optical system 4.

This scanning optical system 4, as shown in Figs. 1 and 2, includes a polygonal scanner 9 for horizontally scanning a laser beam, relay lenses 10, 11 commonly used as a variable lens, a galvano scanner 12 for changing the horizontal scanning position of the polygonal scanner 9 to a vertical direction, a relay lens 13, a focus lens, a reflecting mirror 15, an objective lens 16, etc. Such scanning optical system 4 scan projects the laser beams from the lasers 1, 2 and 3 to the retina Ef of the eye to be tested in accordance with the operation of the scanners 9, 12 to illuminate the retina Ef. The scanning range of the retina by the scanning optical system 4 can be changed to 20° −60° by the relay lens.

The reflected light from this retina Ef can be taken off through the light receiving optical system 4. This light receiving optical system includes the scanning optical system 4, the half mirror 6, a lens 17 and a dichroic mirror 18. The dichroic mirror 18 has such characteristics as to reflect the red light and permit the green and blue light to transmit. And, the reflected light taken out by this light receiving optical system and permitted to transmit the dichroic mirror 18 is made incident to a light receiving device 19 such as PTM (photomultiplier), etc. The reflected light by this dichroic mirror 18 is made incident to a light receiving device 20 such as P.M.T. (photomultiplier), etc. Accordingly, when the reflected laser beams of blue, green and red colors reflected by the retina Ef is taken out through the light receiving optical system, the reflected laser beams of blue and green colors are permitted to transmit the dichroic mirror 18 and input into the light receiving device 19. On the other hand, the reflected laser beam of the red wavelength is reflected by the dichroic mirror 18 and input into the light receiving device 20.

Also, a part of the laser beams coming from the lasers 1, 2 and 3, etc. is permitted to transmit the half mirror 16 and made incident to a light receiving element 21 as a reference light receiving device.

And the mirror 8a, the polygonal scanner 9 and the galvano scanner 12 are drive controlled by a

control circuit shown in Fig. 3. This control circuit 22 and its operation will now be described with reference to Figs. 1 through 5.

Upon actuation of the control circuit 22, the polygonal scanner 9 is rotated at a high speed rate in accordance with a signal from a clock oscillator 24 of a synchronous control circuit 23 through a driver 25. When the laser beams are generated from the lasers 1, 2 and 3, etc. in the foregoing state, the polygonal scanner 9 of the scanning optical system 4 horizontally scans the laser beams to the retina Ef by the number of reflecting surfaces every time the polygonal scanner 9 makes one rotation. On the other hand, the polygonal scanner 9 outputs a horizontal synchronous signal every time the laser beam is made one horizontal scanning to the retina Ef as described. And this horizontal synchronous signal is input into a scanning signal counter 26, a sampling control portion 27, and a synchronous signal generating portion 28. A clock signal is input into the sampling control portion 27 and the synchronous signal generating portion 28 from the clock oscillator 24.

The scanning signal counter 26 counts the horizontal synchronous signal coming from the polygonal scanner 9 and inputs a scanning position change signal into a vertical synchronous control portion 29 every time the horizontal synchronous signal is input. And the vertical synchronous control portion 29 outputs a vertical synchronous signal upon input of this scanning position change signal in order to cause a driver 30 to rotate the galvano scanner 12 by a predetermined angle to displace the horizontal scanning position downward by a predetermined pitch. Also, when scanning lines of the laser beam for one frame portion are scanned, a one frame scanning end signal is input into the vertical synchronous signal control portion 29 from the scanning signal counter 26 and an optical path switch signal is input into mirror pivot driving means such as a solenoid, etc. of the optical path switch device 8.

By this, the vertical synchronous control portion 29 returns the galvano scanner 12 to the original scanning portion. On the other hand, the optical path switch device 8 is actuated by the optical path switch signal. And when the mirror 8a of this optical path switch device 8 is inserted into the optical path, the mirror 8a is taken out of the optical path, whereas when the mirror 8a is removed out of the optical path, the mirror 8a is inserted into the optical path. A switching state of this mirror 8a is maintained until the next signal is input.

This scanning number is different depending on the switching state of a NTSC/HDTV switch 31. That is, when the NTSC/HDTV switch 31 is at the NTSC side, the polygonal scanner 9 is scan driven at 15.75KHz and the galvano scanner 12 is driven at 30Hz, and the number of the scanning lines becomes 525 for one frame portion. On the other hand, when the NTSC/HDTV switch 31 is at the HDTV side, the polygonal scanner 9 is driven at 15.75KHz and the galvano scanner 12 is scan driven at 15Hz, and the number of the scanning lines become 1050 for one frame portion.

As the HDTV monitor has scanning lines of 1125 in number, speed is slightly changed when reading and displayed. Owing to the foregoing construction, a high resolution image can be photographed by scan driving at a comparatively low speed according to necessity.

On the other hand, the vertical switch signal and one frame scanning end signal are input into a memory synchronous control portion 32 and the synchronous signal generating portion 28 from the scanning signal counter 26, and the vertical synchronous signal is input into the memory synchronous control portion 32 from the vertical synchronous control portion 29. Synchronous signals are input into first and second memories 33 and 34 and a reading control portion 35 from this memory synchronous control portion 32. Similarly, control signals are input into the memories 33 and 34 from the reading control portion 35.

Also, output signals are input into the memories 33 and 34 from the light receiving devices 19 and 20 through an A/D converter 36. This A/D converter 36 is controlled by the sampling control portion 29 and output signals are input into the memories 33 and 34 from the light receiving devices 19 and 20. This input timing is performed every time a laser beam spot to be scanned to the retina Ef is moved for one portion.

Such spot quantity (image information signal) for each spot is memorized in sequence at predetermined addresses of the memory 33 by the memory synchronous control portion 32 every time one horizontal scanning is effected. That is, when the mirror 8a is removed out of the optical path, a blue reflected laser beam from the retina Ef is memorized in sequence in a predetermined address of a memory portion B of the memory 33 by the memory synchronous control portion 32 every time one horizontal scanning is effected. And when a memory construction of image information signals for one frame portion has been built up in the memory portion B and the mirror 8a has been inserted into the optical path, a green reflected laser beam from the retina Ef is memorized in sequence in a predetermined address of a memory portion G of the memory 33 by the memory synchronous control portion 32 every time one horizontal scanning is effected and a red reflected laser beam from the retina Ef is memorized in sequence in a predetermined address of a memory

portion R of the memory 33 by the memory synchronous control portion 32 every time one horizontal scanning is effected. As a result, a memory construction for one frame portion is built up in the memory portions G and R. The memory to the memory portions G and R are effected by one frame scanning.

When a memory action to this frame memory 33 has been finished, a memory action to the frame memory 34 is performed in the same manner. And such memory actions to the memories 33 and 34 are repeated.

And when a memory construction to the memory 33 has been finished and a memory action to the memory 34 is started, image information of the various memory portions B, G and R of the memory 33 is output by a read control portion. On the other hand, when a memory construction to the memory 34 has been finished and a memory action to the memory 33 is started, image information of the various memory portions B, G and R of the memory 34 is output by the read control portion. The image information of B, G and R output from the memories 33 or 34 is input into a display circuit 38 through a D/A converter 37, and this display circuit 38 composes one color retina image from the image information of B, G and R. The A/D, D/A and memory circuit A of Fig. 3 include the memories 33 and 34, A/D converter, D/A converter, etc. shown in Fig.4.

Such composed image signal is input into an NTSC monitor 40 or an HDTV monitor 41 through a switch circuit. A synchronous signal is input into the display circuit 38 from the synchronous signal generating portion 28, and a signal is input into the switch circuit from the NTSC/HDTV switch 31.

Also, when laser beams emitted from the lasers 1, 2 and 3 are made incident into the scanning optical system 4, the laser beams are detected by the light receving device 21. And output from the light receving device 21 is input into a light quantity control portion in order to control the lasers 1, 2 and 3 so as to make the laser light quantity constant. The respective outputs of the lasers 1, 2 and 3 are set as such that when an image of the various wavelengths is composed, it becomes white in color taking sensitivity of the light receiving element into consideration.

In the above-mentioned embodiment, a retina photographing for one frame portion is performed with a laser beam of one wavelength within B, G and R and a retina photographing for next one frame portion is performed with laser beams of other two wavelengths in order to obtain a retina image of wavelengths of B, G and R. And by composing them, one color retina image is obtained. However, the present invention is not necessarily limited to this. For example, as shown in Fig. 6, it can be designed as such that a retina photographing for one frame portion is performed with two wavelengths of R and G and a retina photographing for one frame portion is performed with laser beams of two wavelengths of R and B in order to obtain a retina image of B, G and R, and by composing them, one color retina image is obtained. In this case, as a retina reflectance is high in R, an overlapping accuracy becomes good when images for two frames are composed and therefore, a clear image can be obtained.

Accordingly, the retina photographing and the monitor reproduction by the memories 33 and 34 are alternatively performed as shown in Fig. 5.

Also, as shown in Fig. 7, it may be designed as such that a half mirror 42 is disposed between the lens 5 and the first laser 1, and two reflecting mirrors 43 and 44 are disposed between the dichroic mirror 7 and the half mirror 42, an optical path 01 between the reflecting mirrors 43 and 44 being disposed in parallel with an optical path 02 between the half mirror 42 and the first laser 1, a rotating plate 45, a generally half portion of which forms a light transmitting portion 45a, being disposed over the two optical paths 01 and 02, the rotating plate 45 being able to be rotated by 180°. In this case, the optical paths 01 and 02 can be switched by rotating the rotating plate 45 by 180°.

Fig. 8 may be designed as such that the rotating plate 45 and the two reflecting mirrors 43 and 44 of Fig. 7 are omitted, and high speed shutters 46 and 47 formed of a liquid crystal, etc. are disposed between the half mirror 42 and the first laser 1, and between the dichroic mirror 7 and the half mirror 42 respectively.

As the present invention has been constructed as described above, there can be provided a laser scanning type eye fundus camera in which a retina color photographing can be performed in a shorter period of time than the conventional laser scanning type eye fundus camera and a clear color retina image can be obtained.

Claims

1. A laser scanning type eye fundus camera including:
laser beam generating means for generating laser beams having wavelengths of three primary colors;
a scanning optical system for scan projecting the laser beams to the retina of an eye to be tested;
switch means for selectively switching laser beams of various wavelengths coming from said laser beam generating means and guiding the same to said scanning optical system;
control means for controlling said switch means so as to selectively switch at least two laser beams

among said three laser beams and permitting said scanning optical system to scan project one frame portion of such selected laser beams to the retina of the eye and also permitting said scanning optical system to scan project one frame portion of two laser beams or less including the remaining one among said three laser beams to the retina of the eye;

a light receiving optical system for taking out a reflected light from the retina of the eye;

first light receiving means for receiving reflected light having two wavelengths among said wavelengths of said three primary colors which are guided by said light receiving optical system;

second light receiving means for receiving a reflected light having the remaining one wavelength among said wavelengths of said three primary colors which is guided by said light receiving optical system; and

image processing means for composing said various primary colors in accordance with output from said light receiving means in order to form a single color retina image.

2.A laser scanning type eye fundus camera according to claim 1, wherein said laser generating means comprising first through third laser emitting elements adapted to emit laser beams of R, G and B, and one laser beam among said R, G and B laser beams, and the remaining two laser beams are optically switched by said switch means so as to guide the same to said scanning optical system.

3.A laser scanning type eye fundus camera according to claim 1, wherein said laser beam generating means comprises first through third laser emitting elements adapted to generate laser beams of R, G and B; and said switch means optically switches a first flux of light including R among said laser beams of R, G and B and one among the remaining two laser beams and a second flux of light including said R and one among the remaining two laser beams and guides the same to said scanning optical system.

4.A laser scanning type eye fundus camera according to claim 1, wherein said switch means includes a quick return mirror disposed in an optical path of said scanning type optical system.

5.A laser scanning type eye fundus camera according to claim 1, wherein said switch means is a rotating disc plate including a semicircular light transmitting portion.

6.A laser scanning type eye fundus camera according to claim 1, wherein said switch means is a liquid crystal shutter adapted to selectively transmit a laser beam.

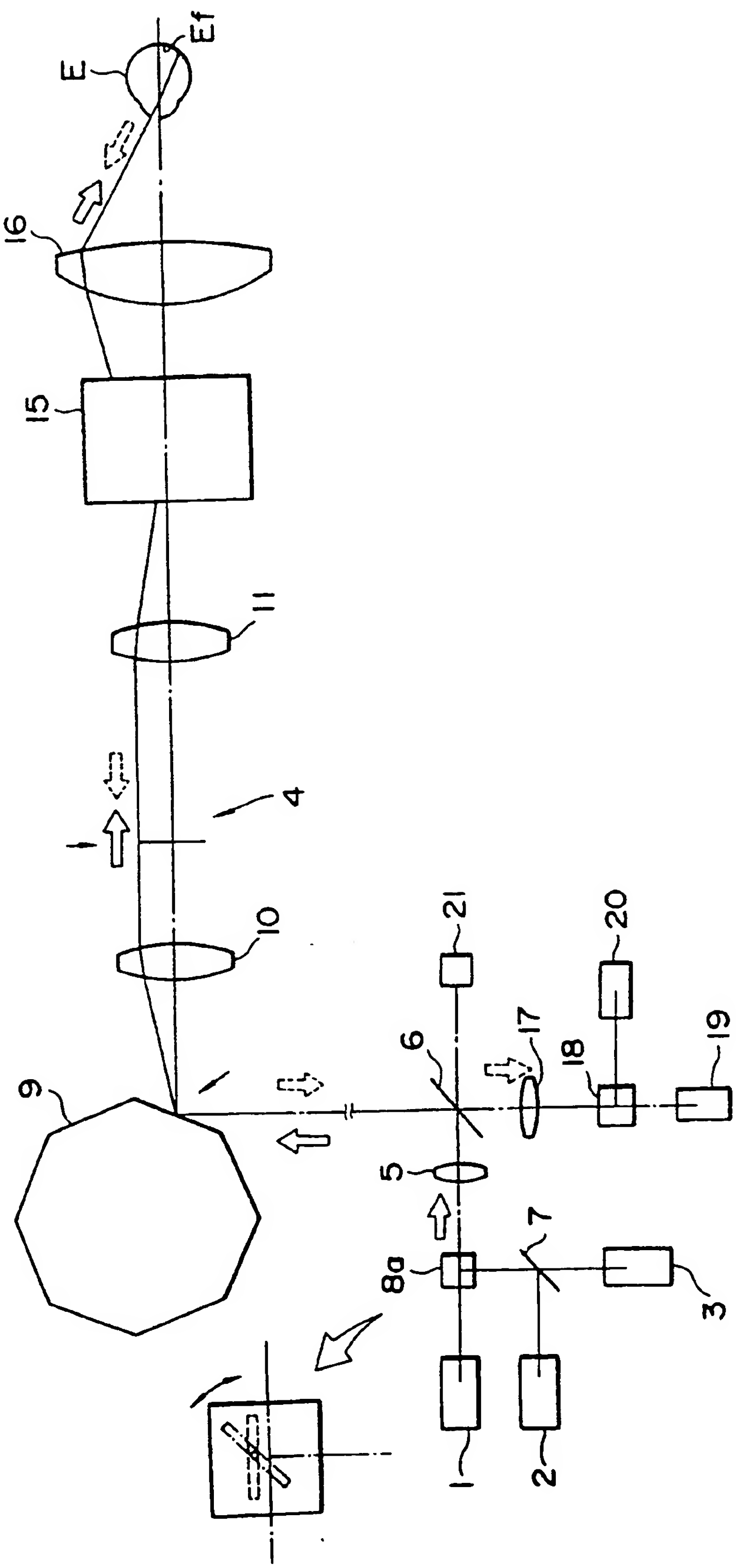


FIG. 1

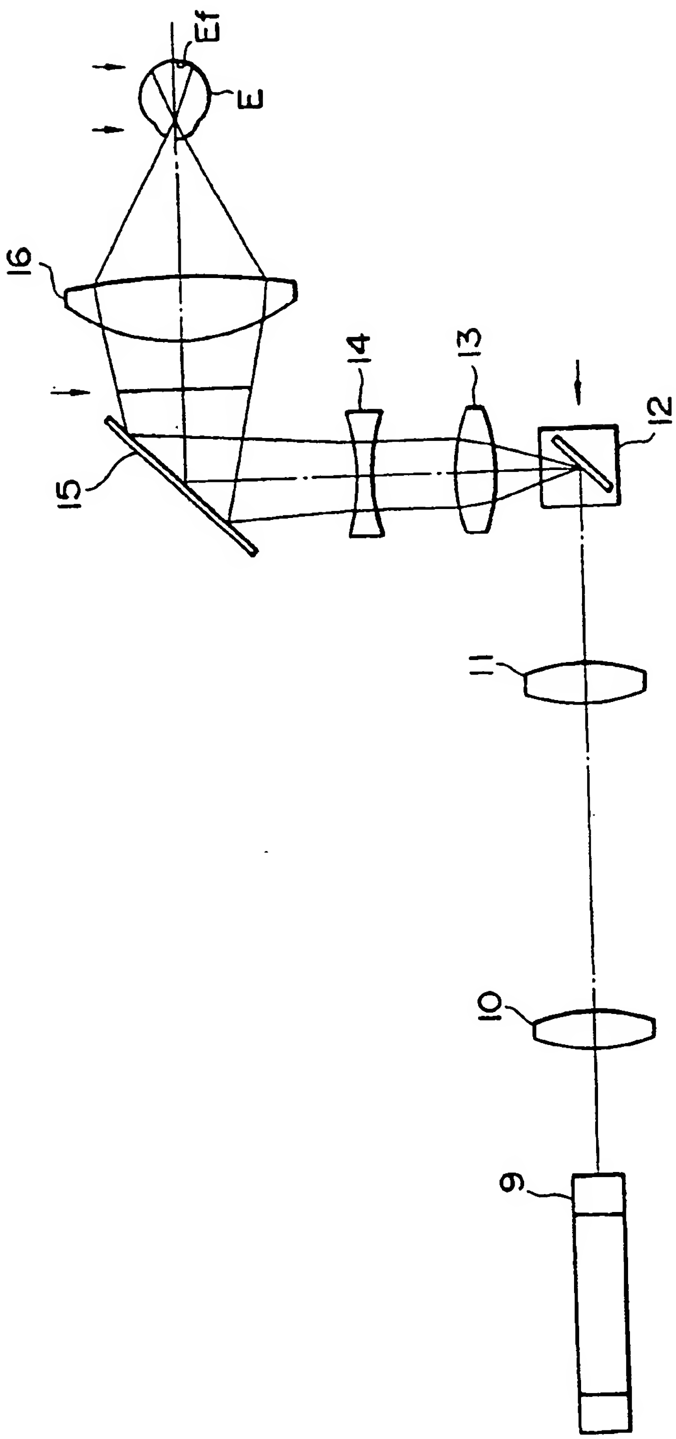


FIG. 2

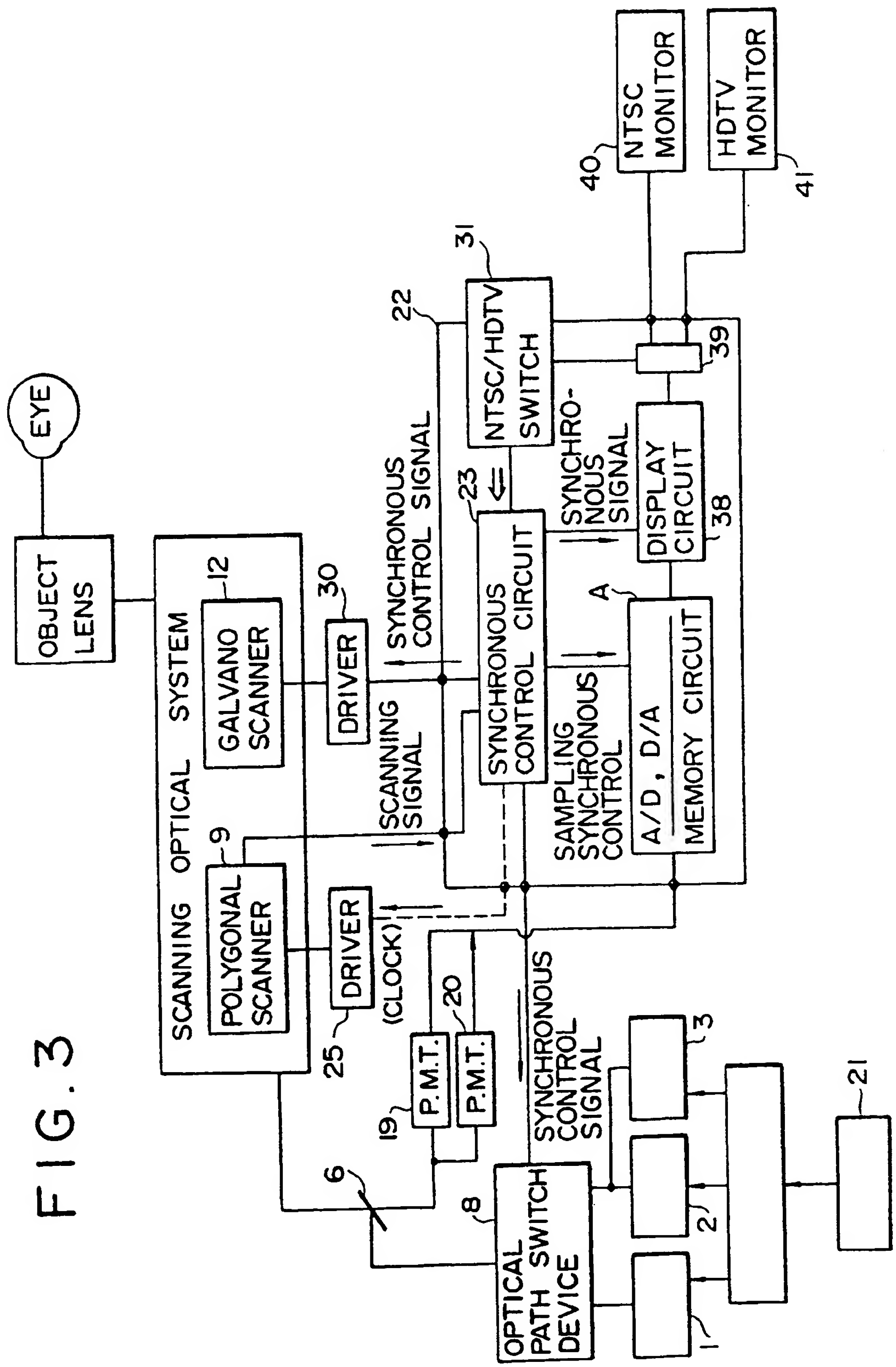
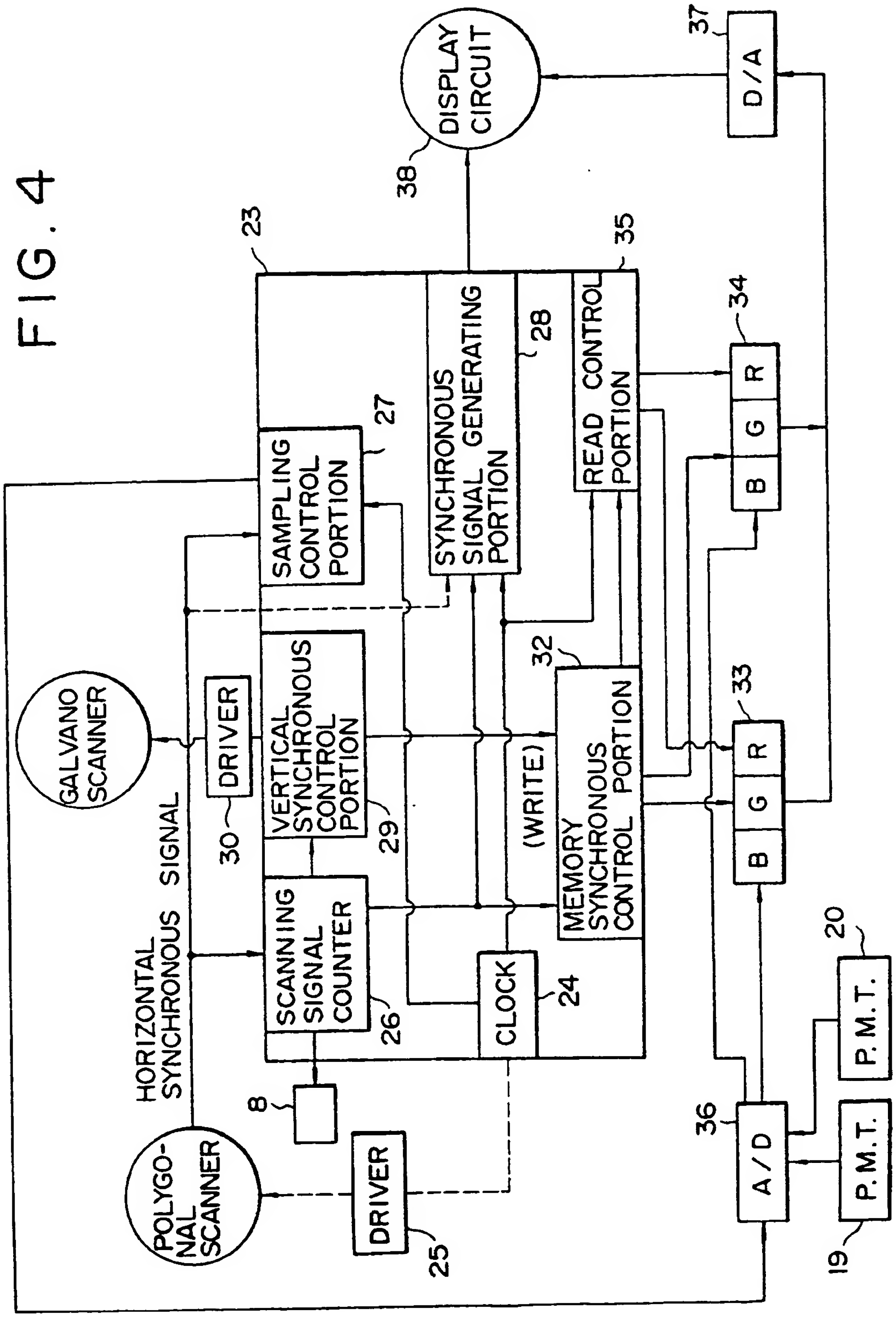

EYE
OBJECT LENS
SCANNING OPTICAL SYSTEM
POLYGONAL SCANNER
GALVANO SCANNER
12
9
30
DRIVER
25
DRIVER
(CLOCK)
SCANNING SIGNAL
SYNCHRONOUS CONTROL SIGNAL
22
SYNCHRONOUS CONTROL CIRCUIT
23
NTSC/HDTV SWITCH
31
SYNCHRO-NOUS SIGNAL
DISPLAY CIRCUIT
38
39
A
A/D , D/A
MEMORY CIRCUIT
SAMPLING SYNCHRONOUS CONTROL
NTSC MONITOR
40
HDTV MONITOR
41
P.M.T.
19
P.M.T.
20
SYNCHRONOUS CONTROL SIGNAL
6
8
OPTICAL PATH SWITCH DEVICE
1
2
3
21

FIG. 3



DISPLAY CIRCUIT
D/A
SYNCHRONOUS SIGNAL GENERATING PORTION
READ CONTROL PORTION
SAMPLING CONTROL PORTION
VERTICAL SYNCHRONOUS CONTROL PORTION
MEMORY SYNCHRONOUS CONTROL PORTION
(WRITE)
SCANNING SIGNAL COUNTER
CLOCK
DRIVER
GALVANO SCANNER
HORIZONTAL SYNCHRONOUS SIGNAL
POLYGO-NAL SCANNER
DRIVER
A/D
P.M.T.
P.M.T.
B G R
B G R
8
19
20
23
24
25
26
27
28
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30
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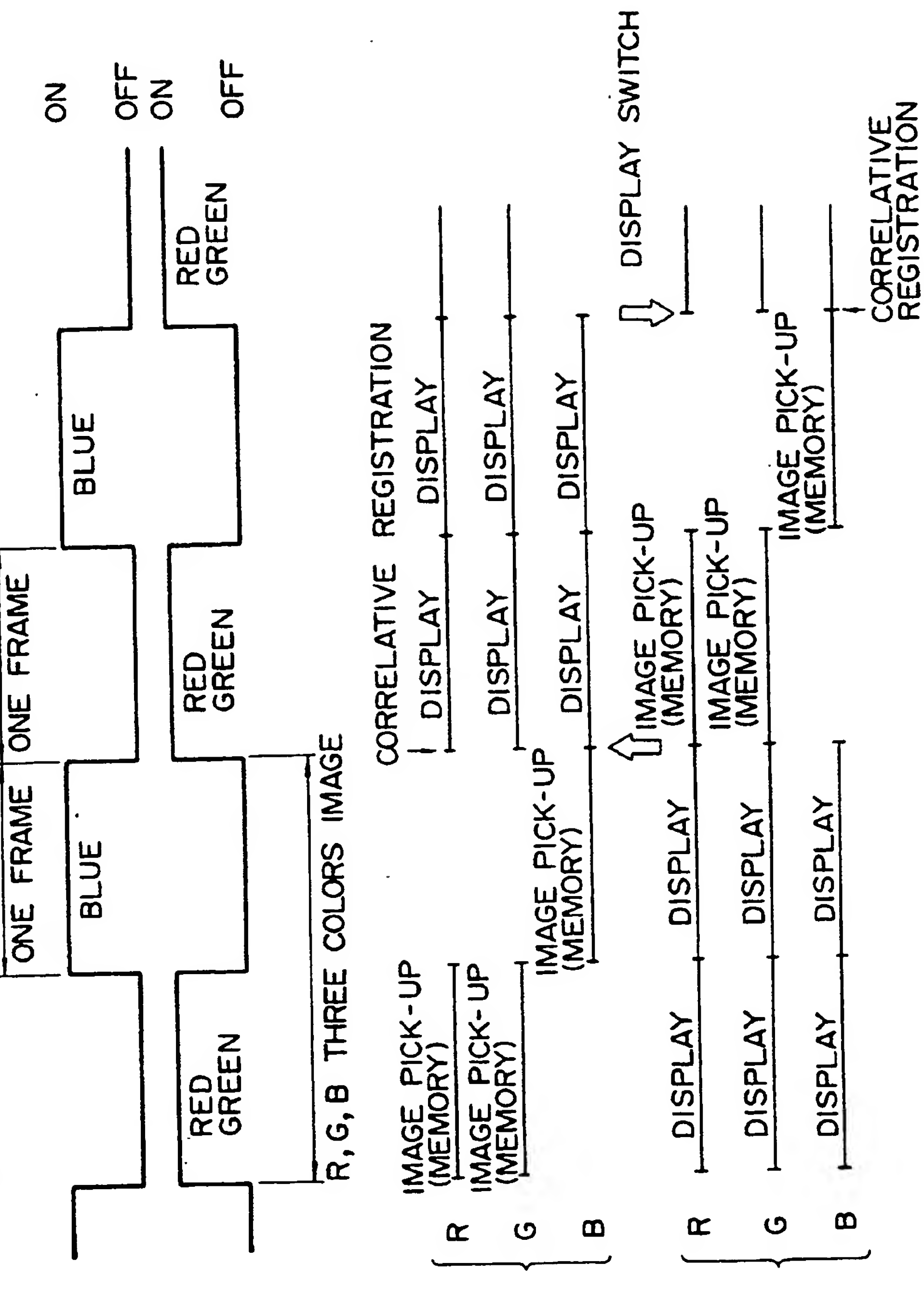
37
38

FIG. 4

FIG. 5



ON
OFF
ON
OFF
1/30sec
ONE FRAME
1/30sec
ONE FRAME
RED
GREEN
BLUE
RED
GREEN
BLUE
RED
GREEN
R, G, B THREE COLORS IMAGE
CORRELATIVE REGISTRATION
R
G
B
IMAGE PICK-UP (MEMORY)
IMAGE PICK-UP (MEMORY)
IMAGE PICK-UP (MEMORY)
DISPLAY
DISPLAY SWITCH
CORRELATIVE REGISTRATION

FIG. 6

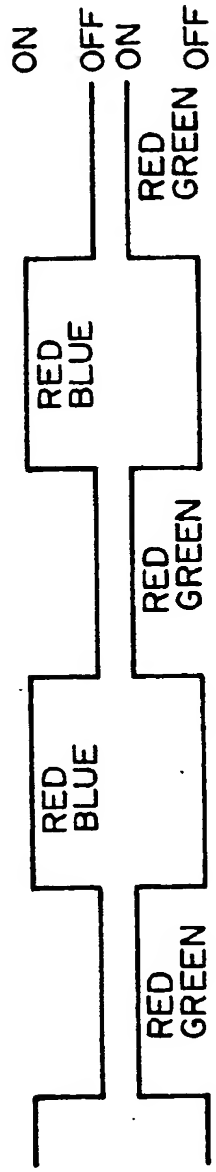


FIG. 7

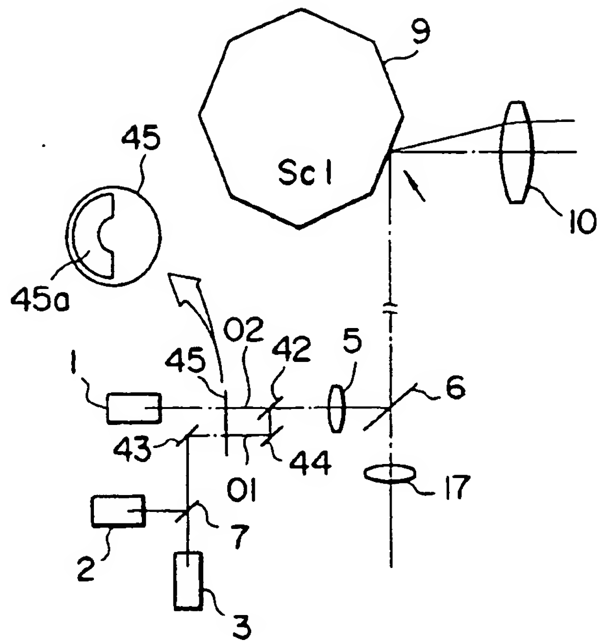
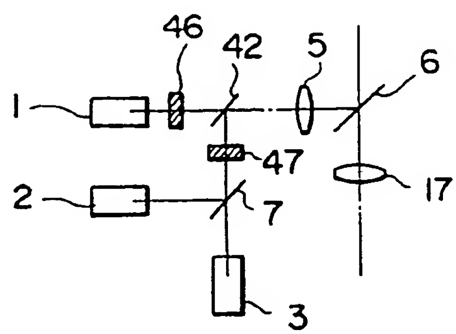


FIG. 8



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 40 3235

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US-A-4781453 (K. KOBAYASHI) * column 3, line 53 - column 5, line 41 * * figure 1 *	1-3	A61B3/12
Y	EP-A-284248 (KOWA CO., LTD.) * column 3, line 51 - column 6, line 55 *	1-3	
A	* figures 1-7 *	4, 5	
A	EP-A-279589 (EYE RESEARCH INSTITUTE OF RETINA FOUNDATION) * column 4, line 42 - column 6, line 39 *	1-3	
A	US-A-4604992 (K. SATO) * column 2, line 38 - column 3, line 68 * * column 5, line 14 - column 8, line 51 * * figures *	1-3, 5	
A	US-A-4807026 (K. NISHIOKA ET AL.) * column 6, line 30 - column 9, line 36 * * figures *	1-3, 5	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A61B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 JANUARY 1991	RIEB K.D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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O : non-written disclosure
P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document